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Carbon/Titanium-Based Composite Materials as Negative Electrodes for Sodium-ion Batteries

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Hard carbon appears as the most promising negative electrode material for Na-ion batteries (NIBs). State of the art electrochemical performances exhibit capacities higher than 300 mAh.g⁻¹ and operating voltage below 0.2V¹. It can be produced through the pyrolysis of numerous readily available, eco-friendly precursors, including biomasses, biopolymers, and synthetic polymers¹. However, some drawbacks have been evidenced and limit large-scale introduction of NIBs for xEV application. One of the main drawbacks is the low volumetric density as compared with graphite.

Titanium-based materials, in particular titanates, are another important class of anode materials with diverse applications in rechargeable batteries. Their use in Li-ion batteries can be attributed to notable advantages such as high power, excellent stability, and abundance, low cost and environmental friendliness. Regarding NIBs, Na₂Ti₃O₇ has been identified as a promising anode material². Its theoretical capacity is around 177 mAh g⁻¹ with the lowest average insertion potential of 0.3 V (vs. Na⁺/Na) ever reported for a Ti-based oxides. Moreover, its high volumetric density close to 4 g.cm⁻³ makes it a very good candidate for high volumetric energy and power density.

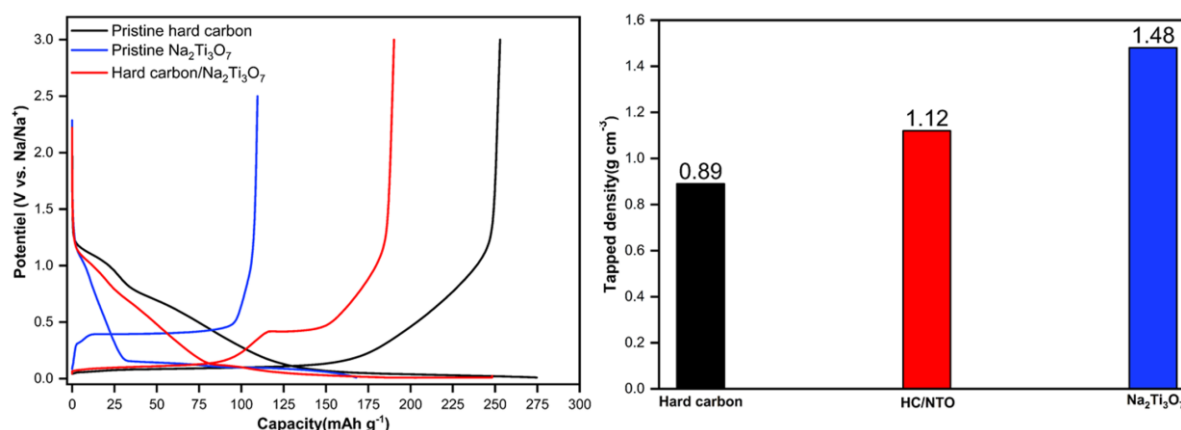


Figure 1 : First charge/discharge profiles at C/20 (a) and the corresponding values of tapped density (b)

In this work, various titanium/carbon-based composites with higher-density active materials were prepared with different ratios using various methods (i.e., solid-state and solvothermal reactions),

¹ C. Matei Ghimbeu, A. Beda, B. Rety, H. El Marouazi, A. Vizintin, B. Tratnik, L. Simonin, J. Michel, J. Abou-Rjeily, R. Dominko. *Advanced Energy Materials* (2024), Review accepted.

² P. Senguttuvan, G. Rousse, V. Seznec, J-M. Tarascon, M-R. Palacín. *Chem. Mater.* 2011, 23 (18), 4109–4111

focusing on examining the material's morphology, surface chemistry and structure, as well as their impact on electrochemical performance. Figure 1 shows preliminary results on non optimised commercially available materials. It reveals interesting electrochemical performances between those of hard carbon and $\text{Na}_2\text{Ti}_3\text{O}_7$, consistent with expectations. An initial discharge capacity of almost 200 mAh.g^{-1} and a Coulombic efficiency of 76.6% were observed for the composition containing 40% $\text{Na}_2\text{Ti}_3\text{O}_7$. Notably, the composite exhibits a tapped density of 1.12 g cm^{-3} , marking a significant enhancement compared to hard carbon.